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**HYDROPOWER AND THE ENVIRONMENT:
A CASE STUDY AT GLEN CANYON DAM**

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Abstract

The management of hydroelectric resources in the Colorado River requires a balancing of hydrologic, social, natural and cultural resources. The resulting management often has to deal with inherently conflicting objectives, short and long-term goals, time frames and operational flexibility. Glen Canyon Dam, AZ, on the Colorado River, controls the release of water into the Grand Canyon. The dam has been under intense public scrutiny since it was completed in 1963. An Environmental Impact Statement evaluating the future operations and options for Glen Canyon Dam was initiated by the Department of the Interior in 1989 and completed in 1995.

An Adaptive Management approach to future operational management has been developed as part of the Glen Canyon Dam Environmental Impact Statement process. Future operations at Glen Canyon Dam will take into consideration the need to balance water movement and hydroelectricity development with natural, recreation, Native American and cultural needs. Future management of rivers requires acknowledgement of the dynamic nature of ecosystems and the need to link scientific information into the decision-making process. Lessons learned and programs developed at Glen Canyon Dam may be applied to other river systems.

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Introduction

The Colorado River and development of the Southwestern United States are tied to one another. The Colorado River through the Grand Canyon was one of the last places in the continental United States to be explored and today represents one of the most controlled water courses in the country.

In the last quarter of the nineteenth century the Western United States was being inundated and populated by people looking for a new start and opportunity for expansion. The Jeffersonian approach of the individual farmers and land control, defined in the East and Midwest, did not work in the arid and often hostile lands of the West. It was recognized in the late 1800's that the only way to make the "desert bloom" required a cooperative approach to develop (i.e. control) the waters of the Colorado River for beneficial use. This required efforts to control the erratic natural flows for the benefit of mankind. The Federal government and the states established a partnership for development of the Colorado River resources. From that point on, dams and the Colorado River were linked, for better or for worse.

Controls of the Colorado River system are both administrative and physical. The Colorado River Compact of 1922 forms the base for the administrative control. Glen Canyon Dam, immediately above the separation point between the Upper and Lower Colorado River basins and the Grand Canyon, defines the control of the physical, cultural and biological resources in the river downstream. Glen Canyon Dam is an impressive structure. Towering over 700 feet above the river it restrains and regulates the flows downstream. Today it also represents a focal point for change in the historic way that the Bureau of Reclamation manages the river.

This discussion is about how the historical ways of management of the Colorado River and Glen Canyon Dam are being updated to reflect the expanding demands of the public and the resource managers. Included in this discussion is a description of the Adaptive Management Program being established for Glen Canyon Dam.

Background

The pre-development Colorado River was a single entity flowing from the headwaters in the Rocky and Wind River Mountains to the Sea of Cortez. The unconstrained Colorado River exhibited wildly fluctuating characteristics. High spring floods followed by trickles in the fall and winter. Before the incursion of settlers, the Native American peoples indigenous to the Southwest were taking advantage of the seasonal vagaries of the river and were utilizing the tributaries of the Colorado River for water for irrigation. The Hohokam people, in the area of what is today Phoenix, developed an extensive irrigation system. Seasonal uses of the river water also occurred along the river by the Hopi and Paiutes -the first forms of flood irrigation and using the newly laid down and wetted sediments for the planting of corn and grains.

With the expansion of settlement into the West a more extensive river control was required. First it followed the actions of the native peoples with water diverted from easily controlled locations such as in the Grand Valley, CO and Yuma, AZ areas. However as more people flooded the West a need existed to control the "Rio Colorado" for more expansive development.

Federal government activities in the Colorado River Basin began in the early 1900's not long after the Bureau of Reclamation came into existence. Initial activities dealt with basin planning and small scale developments in cooperation with local water districts. However in the 1920's the Colorado River Basin States realized that long-term development required consistent water, low cost and dependable power and control of the widely variable flows. After much negotiation the Colorado River Compact was signed in 1922 between the seven Colorado River Basin States and the Federal government. The Compact opened the door to Federal development of dams and irrigation projects, in cooperation with the states, for the Colorado River.

Boulder Dam, renamed Hoover Dam in 1947, was the first major federal dam on the Colorado River. Hoover Dam was authorized by Congress in 1928 and completed in 1935. As the lower basin, and specifically California's desire for more water continued to expand, the Upper Basin, concerned over losing control of their own water destiny, decided on a more comprehensive water development strategy and established with

Congress the Colorado River Storage Project Act in 1956. This Act provided the vehicle for the building of Glen Canyon Dam and several other dams and irrigation projects in the Upper Basin. Construction began in 1956 and was completed in 1963.

When Glen Canyon Dam was authorized for construction by Congress there was no legal, or administrative requirement for any environmental review or assessment. The primary concern that did exist focused largely on salvage activities in the Lake Powell reservoir basin. No downstream effects were evaluated or taken into consideration in the anticipated operations of Glen Canyon Dam.

In 1970 the National Environmental Policy Act (NEPA) was signed into law and brought with it legal requirements for review of federally funded projects. NEPA historically has looked at future impacts and has not been used for evaluating past actions. Following NEPA have been a formidable assemblage of environmental and cultural resource laws including the Endangered Species Act and the Clean Water Act.

Case Study: Glen Canyon Dam Environmental Impact Statement

In 1982 Reclamation was faced with a need to initiate some essential maintenance and upgrades to the Glen Canyon Dam eight generators. This work, post 1970, required NEPA review to support the proposed actions. During the NEPA process the public identified many concerns regarding the impact that the operations of Glen Canyon Dam was having on the downstream natural and recreation resources in the Grand Canyon. To allow for the work at the dam to proceed, Reclamation, with concurrence from the Department of the Interior, initiated the Glen Canyon Environmental Studies (GCES) as part of the formal Environmental Assessment on Glen Canyon Dam (1982). The initial GCES program had two primary objectives:

1. To qualify and quantify the impacts that the operation of Glen Canyon Dam was having on the downstream natural and recreation resources in the Grand Canyon, and
2. To determine if there were any means, within the existing legally defined operational mandates, for operating Glen Canyon Dam that reduction of those impacts could be achieved.

The initial phase of the GCES program ran from 1983 through 1988. GCES was a scientific approach that was to identify if more extensive NEPA compliance would be required regarding dam operations and the effect on the downstream resources. Phase I results addressed the two primary objectives in a series of technical reports and a formal review of the scientific process and results through the National Research Council (1989). The results of GCES Phase I identified that the dam operations were having impacts to the downstream ecosystem and that there were abilities within existing Colorado River operational mandates that could mitigate some of those impacts.

In July 1989, after considerable review by the Department of the Interior and the resource agencies, a decision was made to initiate an **after the fact** full EIS evaluation on the operations of Glen Canyon Dam. This EIS process culminated in a final EIS being submitted to the Secretary of the Interior in March of 1995 (DOI, 1995). The GCES program, Phase II, continued to provide the technical expertise and assessment of the impacts of the operations and the design of an ecosystem based approach to operational evaluations.

In the GCES Phase II program the focus changed from a basic broad-based approach to understanding resources, to evaluation of ecosystem processes and specific resource impacts. In addition to the natural and recreation resource studies, the research effort expanded into the arenas of cultural resources, Native American and economic studies. A full listing of the technical reports is available in Wegner (1995).

In 1992 Congress determined that additional guidance was needed for Reclamation regarding the specific NEPA process, timelines and products and passed the Grand Canyon Protection Act (P.L. 102-575). The Act also defined who was to be involved in the decision process and the development of a future management approach.

The Glen Canyon Dam EIS defines a series of operational options that include a baseline focused on monthly and annual flow volumes and daily operations. Coupled with the daily operations are annual Habitat Maintenance Flows, defined as being above normal operations but within powerplants capacity, and Habitat Building Flows, which are "controlled" high flow releases to allow for the movement of sediments from

the river channel to the sides of the river. Efforts are also being made to evaluate structural modifications to the dam to mitigate some of the overlying impacts, namely temperature, through the use of Selective Withdrawal Structures and flood control regulations.

Adaptive Management at Glen Canyon Dam

When Glen Canyon Dam was completed in 1963, there were a relatively small list of mandates and constraints that defined operations. They included the Colorado River Compact, the filling criteria for Lake Powell and several court decisions on water allocations downstream. In 1968, the passage of the Colorado River Basin Act (P.L. 90-537) defined several additional operational mandates for managing water. Beginning in the 1970's and culminating with the recently completed EIS, additional and more expansive mandates have entered the scene. These new mandates including the Endangered Species Act, NEPA, Clean Water Act, and a wide array of cultural resource laws and directives, must be balanced against the historical mandates. It is obvious that the role of the traditional water manager has changed. The question is how to deal with the often conflicting mandates and resources that don't follow the same timeline as the environmental resources?

Adaptive Management has been defined (Lee 1993) as "an approach to natural resource policy that embodies a single imperative: policies are experiments; learn from them." In the Colorado River basin history has shown extensive use, and some would say abuse, of the resources and that we do not understand the ecosystem well enough to determine how to live in balance within the environmental limits. The Adaptive Management for Glen Canyon Dam acknowledges that scientific information and data is an important part of the process of dam management and that we don't have all of the answers to the myriad of ecosystem variations that may arise.

Key to the Adaptive Management discussion is that information has value and that special care must be taken with how it is collected and used. Explicit planning must go into what elements of the ecosystem are important, the design methods to evaluate impacts, and determination of what specifically needs to be measured. Consistent with the planning effort must be specific methodologies to collect and analyze the

information so that expectations and predictions can be compared with reality. Lastly, the link to better policy and management must be made. This entails transforming and demistifying the scientific information into documents and formats that decision makers can use in the fine-tuning and, if necessary, correcting operations and management to meet the goals of the program.

Quite simply, the Adaptive Management program is predicated on learning by doing and accepting the fact that long-term operations require a continual refinement if we are to meet the expanded list of mandates that direct Glen Canyon Dam's future.

Adaptive Management is identified in the Glen Canyon Dam EIS as the preferred process for future decision making. It is composed of three equally balanced elements; a technical process, an administrative-coordination process, and a decision process (figure 1). Key to its success is communication and coordination.

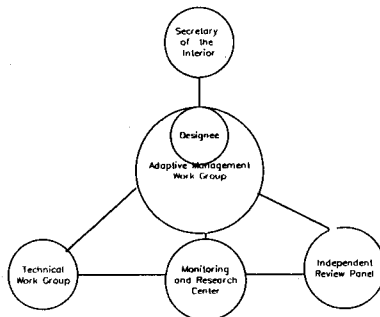


Figure 1. Adaptive Management Process

Technical Process. The technical element of the Adaptive Management program will be established around a definitive long-term monitoring and research program that will focus on key elements and indicators of the ecosystem. Franklin (1988) identified that long-term monitoring is needed for evaluation of: slow processes; rate events, episodic events, processes with high annual variability, subtle processes and complex phenomena. All of these elements fit the ecosystem responses in the Grand Canyon.

The long-term monitoring program is being built from the information collected and analyzed through the GCES Phase I and II programs and other pertinent historical information. The information is being synthesized into computerized data bases and a Geographic Information System that will focus on 15 long-term monitoring sites and three special study sites in the Grand Canyon (Werth, 1993). Non-electronic information will be archived within a Scientific Information Management System that will allow cataloging and easy access to the researchers and the public.

The long-term monitoring program is presently being completed and specific elements of it will be implemented in 1996. Short-term research, to support the evaluation and understanding and interpretation of long-term monitoring results and ecosystem processes, will be developed as appropriate. To provide an outside review of the long-term monitoring program an independent technical review committee will be established. Annual and special study reports will be developed to document specific changes and the status of the Grand Canyon riverine ecosystem.

Administrative Coordination Process. A critical element identified in the EIS process was the large number of specific, and non-specific, management mandates, objectives and criteria that need to be balanced in the management of the operation of Glen Canyon Dam. Management process now requires much more than moving water downstream. To assist in the identification of specific management objectives and to provide assistance and direction to the long-term monitoring program a Technical Work Group is being established. This work group will be composed of managers from the individual resource agencies, Tribes and user groups who have specific expertise and management responsibilities.

The primary objective of the Technical Work Group is to provide administrative assistance and guidance, interpretive direction, assistance in permits, formulation of operational options, identification of agency mandate inconsistency, budget coordination within and among agencies, and initial recommendations on any needed operational refinements.

Recommendation Process. The development of specific operational refinements will be accomplished through the Adaptive Management Work Group. This

group, composed of decision-makers from the various agencies, Tribes and public interest groups will serve the role of formulation of the recommendations to the Secretary of the Interior for any potential changes in the operations of Glen Canyon Dam. A Department of the Interior representative will coordinate the Adaptive Management Work Group activities. This group will be formed under the Federal Advisory Council mandates to allow for complete and open discussion of all results, identified impacts and proposed recommendations.

Annually the Adaptive Management Work Group will submit a report to the Department of the Interior on the state of the health of the Grand Canyon riverine ecosystem and identify any specific recommendations for dam operation changes that should be considered. Any specific operational modifications must be initiated through the Secretary in compliance with the mandates identified in the EIS, the Grand Canyon Protection Act and tied back to the annual operations plan for the Colorado River.

Summary

The completion of the EIS for the future operations of Glen Canyon Dam represents a significant change in the historic ways of operating and managing Glen Canyon Dam. The completion of the EIS also represents an **opportunity** for a significant step forward in managing complex riverine ecosystems for one of the most famous river ecosystems in the world, the Grand Canyon.

The GCES and EIS programs have been long and arduous processes. Initially fraught with inconsistent and often uncoordinated approaches to science and management, a great deal of trepidation over administrative objectives, and more than a little bit of concern over the uncertainty of where the process was taking us. Out of these often anxious times was born a process. A process predicated around the legal mandates broadly defined by NEPA but expanded upon to allow for new ideas, communication and recommendations to evolve. In the case of Glen Canyon it is true that the sum of all the efforts is far more impressive than the individual efforts.

Historically technology and all its associated trappings have been viewed as the cure-all for any problems that may arise. Technology in the form of building dams, developing irrigation projects, building

hatcheries have been seen to be the panacea for many problems. One thing we have learned is that in many cases technological problems increase in direct proportion to technological solutions. What is needed is a recognition that better management of the remaining resources is required if we are to maintain what we have left.

Now that the NEPA administrative process for Glen Canyon Dam has been completed, the next phase begins. This effort requires that we build upon what we have learned and the trusts developed. The Adaptive Management idea has evolved out of this process. The Adaptive Management approach for Glen Canyon Dam is an idea whose time has come and if developed properly will provide a solid framework for long-term and multiple resource management of the resources of the Colorado River.

References

Franklin, J.F. 1989. Importance and Justification of Long-Term Studies in Ecology in Long-Term Studies in Ecology. Approaches and Alternatives. Springer-Verlag. New York, N.Y.

Lee, Kai N. 1993. Compass and Gyroscope. Integrating Science and Politics for the Environment. Washington, D.C. Island Press.

National Research Council. 1987. River and Dam Management. A Review of the Bureau of Reclamation's Glen Canyon Environmental Studies. Washington, D.C.

U.S. Department of the Interior. Bureau of Reclamation. Glen Canyon Dam Final Environmental Impact Statement. 1995. Washington, D.C.

U.S. Bureau of Reclamation, Department of the Interior. 1982. Finding of No Significant Impact for Glen Canyon Dam Powerplant Upgrading. UC-FONSI 83-1. Salt Lake City, UT

Wegner, D.L. 1995. Glen Canyon Environmental Studies. Phase II Technical Reports. Flagstaff, AZ.

Werth, L.F., P.J. Wright, M.J. Pucherelli, D.L. Wegner, and D.N. Kimberling. 1993. Developing a Geographic Information System for Resource Monitoring of the Colorado River in the Grand Canyon. U.S. Department of the Interior. R-93-20.